ugust 1979

RESEARCH NOTE RM-372

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Microbial Populations in Undisturbed Soils and Coal Mine Spoils in Semi-arid Conditions[1]

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Microbial populations in undisturbed soils and in coal mine spoils exposed for 1, 8, and 14 years are listed for semi-arid conditions in New Mexico.

Keywords: Microbial populations, soil flora, mine spoils, reclamation.

Introduction

In the vast coal fields of the Western and Southwestern states, much of the coal is less than 33 m below the surface, making strip mining the most economical and feasible method of extraction. Problems of reclamation and revegetation of strip mine spoils are compounded in these semi-arid states by long periods with a lack of moisture and generally very low moisture. Vegetation and other forms of life return very slowly to spoil sites.

This study provided an opportunity to make a single measurement taken in March of microbial population levels on mine spoils 1, 8, and 14 years old, and on two undisturbed sites. Although statistical comparisons cannot be made in this study, it does provide baseline data for microbial populations found on Southwestern mine spoil material; data that at present is lacking in the literature.

Knowledge of how microbial populations fluctuate may be helpful in estimating how quickly coal mine spoils may be revegetated. Since microbes are the decomposers of biomass, large variations in producer and/or consumer biomass levels, or chemical variations, are reflected in the microbial populations. Microbial populations and numbers may possibly be of use in indicating plant species to choose for revegetating mine spoils since microbial populations and numbers show some association with the types of successional plant species, the rate of succession, and the establishment of a stable surface community.

Methods and Materials

Site Characterization

The study was conducted on McKinley mine property located near Gallup, N. Mex., in a semi-arid grassland-forest ecosystem. The two predominant plant species on nearby unmined areas are one-seed juniper (*Juniperus monosperma*) and blue grama grass (*Bouteloua gracilis*) on slopes, and sagebrush (*Artemisia* spp.) and blue grama in the arroyo or valley areas. Both juniper and sagebrush

[1]*Research reported here is a contribution to the SEAM program. SEAM, an acronym for Surface Environment and Mining, is a Forest Service program to research, develop, and apply technology that will help maintain a quality environment and other surface values while helping meet the Nation's mineral requirements. The authors appreciate the cooperation and assistance of the Pittsburgh and Midway Coal Co. in providing study areas, facilities, and manpower for the field investigations. Supervision for this research, funded by the Rocky Mountain Forest and Range Experiment Station, was provided by Earl F. Aldon, Project Leader for Mine Spoil Reclamation in the Southwest research, at the Station's Research Work Unit in Albuquerque, in cooperation with the University of New Mexico. Station's central headquarters is in Fort Collins, in cooperation with Colorado State University.*

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sites were studied in the unmined areas. The average rainfall is less than 25 cm per year, with nearly half occurring in July through October.

Mining began at the McKinley site in 1961; spoil areas 1, 8, and 14 years old were available for study. The spoils were the mixed overburdens of the coal seams, and varied greatly in textures due to mixing of various strata. Site variables were kept as constant as physically possible.

Sampling Procedure

Microbial populations were studied from both undisturbed soils and mine spoils. In the undisturbed soils, samples were taken from depths of 0 to 20 cm, 20 to 35 cm, and 35 to 50 cm in both the juniper and sagebrush areas. A composite sample from a depth of 0 to 35 cm was taken in the three age classes of spoil material.

Chemical properties were determined by standard laboratory procedures of the New Mexico State University Soil and Water Testing Laboratory.

Media and Cultivation

Serial dilutions of each soil were made in water and plated on enrichment media (Waksman and Fred 1922). The enrichment media (table 1) were prepared for the isolation of aerobes, anaerobes, microaerophils, yeasts, fungi, actinomycetes, nitrate reducers, nitrogen fixers, and sulfate reducers. Three replicates of each serial dilution were made and colony numbers averaged.

In addition, fungal populations were isolated and characterized by an organic trap technique.[3] Fungi were then counted and characterized as to genus.

Results

In the unmined juniper and sagebrush areas, bacterial populations decreased as depth below the surface increased. Bacterial populations were higher under sagebrush than under juniper. The populations in both soils were usually around 10^5 organisms per gram of soil in the upper soil horizons, decreasing to 10^4 organisms in the deeper horizons. A typical diagram for nitrogen fixing bacteria is shown in figure 1.

A listing of microbial populations in mine spoils exposed 1, 8, and 14 years is shown in table 2. Chemical characteristics of the spoils are shown in table 3.

A few genera of fungi became established after 1 year (table 4). After 8 years, there was a greater diversity and number of individuals in the population, and two antibiotic fungal species emerged after 14 years.

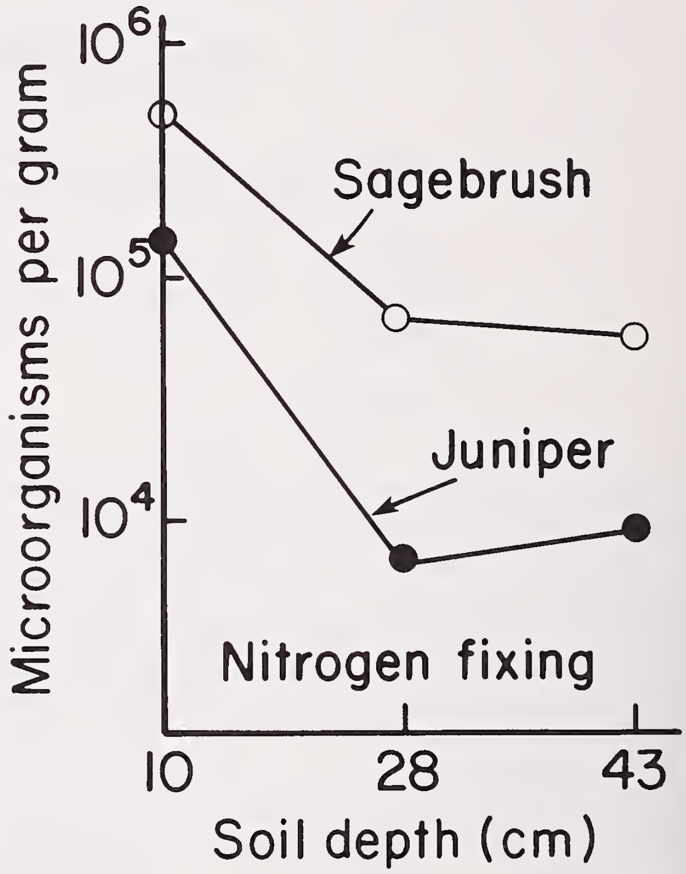

Figure 1.—An example of vertical distribution of bacteria populations in undisturbed soils.

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Table 1.—Media used for isolating microorganisms

Medium	Organisms selected for	Reference
Trypticase soy	Aerobic microorganisms	Rhode (1973)
Czapek dox	Fungi	Czapek (1902), Dox (1910), Thom and Church (1926)
Nitrate reduction agar	Nitrate-reducing organisms	Difco Laboratories, Inc. (1953)
Sulfate reduction	Sulfate-reducing organisms	Adams and Postgate (1961), Butlin et al. (1949)
Yeast isolation medium	Yeasts and aerobic bacteria	
Actinomycete isolation media	Streptomycetes and aerobic bacteria	Difco Laboratories, Inc. (1953)
Nitrogen fixing	Free living N^2-fixing organisms	Parkinson et al. (1971)
Fluid thioglycollate	Microaerophils	Brewer (1940)
Brewers anaerobic	Anaerobic organisms	Brewer (1942)

Table 2.—Average microbial populations from 0-35 cm deep in undisturbed soils and in mine spoil materials exposed 1, 8, and 14 years to semi-arid conditions.

Medium	Mine spoil materials exposed for:			Undisturbed soils	
	1 yr	8 yr	14 yr	Sagebrush	Juniper
Trypticase soy	1.2×10^{5}	1.3×10^{6}	1.3×10^{5}	7.9×10^{5}	6.1×10^{5}
Czapek dox	1.2×10^{5}	5.7×10^{5}	1.4×10^{5}	8.4×10^{5}	1.6×10^{5}
Nitrate reducer agar	2.2×10^{5}	4.0×10^{5}	1.7×10^{5}	7.7×10^{5}	2.5×10^{5}
Sulfate reduction	1.3×10^{2}	1.2×10^{3}	8.2×10^{3}	1.3×10^{4}	7.0×10^{2}
Yeast isolation medium	1.2×10^{4}	1.4×10^{5}	4.6×10^{4}	2.3×10^{5}	2.2×10^{4}
Actinomycete isolation media	2.5×10^{4}	3.2×10^{5}	8.4×10^{4}	3.2×10^{5}	1.2×10^{5}
Nitrogen fixing	1.0×10^{5}	5.1×10^{5}	8.3×10^{4}	3.6×10^{5}	8.5×10^{4}
Fluid thioglycollate	4.6×10^{3}	1.3×10^{5}	4.0×10^{4}	7.2×10^{5}	1.1×10^{4}
Brewers anaerobic	9.8×10^{4}	7.0×10^{4}	4.1×10^{3}	3.5×10^{4}	2.7×10^{3}

Table 3.—Chemical characteristics of undisturbed soils and of mine spoil materials exposed 1, 8, and 14 years to semi-arid conditions

Chemical characteristics	Mine spoil materials exposed for:			Undisturbed soils	
	1 yr	8 yr	14 yr	Sagebrush	Juniper
pH	6.90	6.70	6.95	7.57	7.75
EC$\times 10^{3}$	4.21	2.34	2.75	0.81	0.47
Inorganic C (%)	0.00	0.74	2.07	0.79	0.25
Organic C (%)	4.40	15.52	2.04	0.00	0.02
Total C (%)	4.35	16.26	4.11	0.79	0.28
NO_3- (ppm)	240.00	3.05	29.20	0.16	0.15
Ca^{++} (me/1)	30.25	1.86	21.09	7.65	3.30
Mg^{++} (me/1)	17.12	1.02	6.45	0.97	0.87
Na^{+} (me/1)	15.57	21.42	9.59	0.40	0.73
K^{+}	0.79	0.50	0.18	0.25	0.15
SO_4- (me/1)	41.86	15.73	21.87	0.36	0.54
Cl^{-} (me/1)	2.12	1.10	3.01	0.18	0.12
HCO_3- (me/1)	4.40	5.19	6.85	8.40	4.35
SAR	3.20	23.66	2.50	0.55	0.24

Table 4.—Genera and numbers of microorganisms in mine spoil and juniper soils obtained by the organic trap method.

Genus	Mine spoil age			Juniper soil
	1 year	8 years	14 years	
Alternaria		3		
Basidiomycetes			9	1
Chaetomium		1	3	1
Fusarium		9		9
Myrothecium		1		5
Penicillium		3		
Phoma		1		
Pythium		2		3
Rhizopus		2		
Stachybotrys	9	1		
Tetracocco		2		
Verticillium		2		
Nematodes		2		6
Bacteria	6	7		6
Total Numbers of:				
Genera	2	13	2	7
Individuals	15	36	12	30

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